UMC Education Discussions - October 9, 2008

The State of MSE Departments and MSE Education – Present and Future

Meeting Goals:

1. Identify areas of future focus for UMC and possible collaborative bodies and take appropriate action for exploring next steps.
2. Advise regarding the need for an NRC/NMAB study of materials education at post-K-12 levels.

Suggested Topics:

A. Undergraduate education in MSE and other "materials" departments: Is there a "core" that all can agree on? Can we define a "Body of Knowledge" as has the Civil Engineering Community?

Background: The number of these departments has been decreasing while large departments get larger and small departments are dissolved or absorbed into other engineering departments. More and more of the remaining "materials" departments are taking the name "materials science and engineering" although not all of these have undergraduate degrees.

B. Undergraduate materials majors and/or overview materials courses in <u>other</u> engineering departments: Can we find a way to have influence on what is taught?

Background: Materials knowledge is critical for many practicing engineers. Various approaches to teaching these subjects exist across the academic landscape. We have found how much this can matter when we found that virtually nothing is taught to ME's about corrosion, and yet, it is primarily ME's and CE's that design everything we use.

C. Materials Education beyond the undergraduate engineering degree: Consider both the professional masters degree, continuing education needs and long-distance learning as follow-on strategies to achieve the required "vertical" expertise to succeed in industry.

Background: We increasingly hear about the conflict between covering more and more topics while the number of hours required for a BSE is decreasing. Certainly, expertise is less and less likely at the BSE level. However, little economic advantage exists for those with and MSE degree, so what options are "saleable"?

D. Are there enough common features in MSE departments to allow for (or demand) serious consideration of a "core" graduate curriculum?

Background: The several departments differ much in technical research emphasis and exam structure at the graduate level. Are there enough common elements to justify

this exercise? Do employers care, or do they make decisions at the PhD level on issues such as thesis content, papers published and reputation of the thesis advisor and department?

E. What can we learn from other national efforts, e.g. the UK?

Background: The UK, following Ashby, (UK Centre for Materials Education), has done much of what we might wish to do. Can we merely adopt their approach and results?

F. What are the roles we desire for UMC, professional societies?

Background: In all other professions, committees formed by the single dominant society takes the responsibility for these issues. We are hobbled once again by the multi-society nature of our field. Will one society step forward and take on these issues? Is a multi-society effort such as in the Materials Advantage program a preferable model? See LHS discussion at the close of the memo.

G. Do we need a "study" by the National Academies to assist in sorting out what to do?

Background: The NMAB is now completing its study of corrosion education which sets the stage for a broader study of all issues in undergraduate materials education. Funding is an issue since it will likely require commitment of DOD, DOE and NSF to make this happen. Has this workshop exhausted the NSF appetite on this topic for now?

Issues discussed at the NSF workshop, Sept. 18-19, 2008

1. Should materials science and engineering move towards a professional MS degree as the entry level degree into the profession? What are the pros and cons of such a move?

NSF Workshop Summary: No requirement should be encouraged for a professional master's degree. Complications related to accreditation could lead to more of a mess than MSE departments want or need to deal with. On the other hand, more departments are offering masters degrees without theses.

LHS Comment: This conversation should begin with the recognition of what is happening to the field: reduced numbers and changing demography of departments; "materials" being taught in other fields; too much to teach as the field broadens and the requirements from engineering continue to expand; and finally the rather impossible task of teaching both materials science and materials engineering within a single department for students who may go on to scientific research careers or may go on to do engineering in industry. We must all certainly agree that no undergraduate curriculum can contain all of the content required to "practice", so the real issue is what form the continuing education will take. The underlying question here is really what are the marketable forms that

such advanced education will take. The MIT fully industrial financed approach may work for MIT and a few large corporations, but it doesn't seem to fit a world in which pay scales for MS exceed those for BSE by only a bit (unlike the situation in business, where company sponsored MBA is quite common). My own preferred approach is a non-degree, web-based educational system that enables expanded knowledge in those areas that are job-critical. Such a "system" already exists, but universities are not universally engaged and administrative issues regarding cross-listing and credit acceptance need to be addressed. Other entities such as the ASM continuing education courses continue to thrive indicating a waiting clientele.

2. Importance of "soft' versus "hard" skills in the education of materials scientists and engineers. This question should be considered in terms of the impact of globalization of materials science and engineering and the workforce in general.

NSF Workshop Summary: "Hard" was interpreted as technical, both core and elective, while "soft" skills are those such as working in teams, oral and written presentation, business (including entrepreneurial) skills, ethics, etc. The workshop came down squarely in favor of introducing the "soft" by integrating it into the "hard" and maintaining balance. Helpful?

3. Should materials science and engineering embark on major revolution of its core curriculum? Can both traditional (e.g. corrosion, phase diagrams, etc.) and modern (biology, computational materials science, cyber‐enabled discovery) topics be taught at an appropriate level within the constraints of limited credit hours? Are undergraduate research experiences important to the development of materials scientists and engineers?

NSF Workshop Summary: No revolution required. Current general agreement about "core" (as evidenced in a great study of u.g. curriculum in 15 largest departments presented by Kevin Jones) suggests we have some coherent agreement already. No real consensus was reached on the second fuzzy question (see LHS comments below), but rather, it was asserted that such issues should be addressed in the context of specialization options.

LHS Comments: Clarifying what topics and concepts are properly included as the essence of an engineering degree is a job usually carried out by professional societies (e.g. the Body of Knowledge concept recently developed by the Civil Engineering community through ASCE. In materials, the fragmented nature of the field makes this rather difficult, but leadership by TMS (and possibly NICE) who have managed the ABET process would seem appropriate. Clearly UMC must take a role in this to assist in the data collection and analysis that a TMS committee might organize. There is certainly a need for a common data repository. Will that be TMS, UMC, ASM (the historic home of the Materials Education Yearbook)??? Who, if anyone, will take the leadership role seriously

and coordinate this effort? I expand on this discussion in general comments at the end of this memo.

4. How can the gulf between materials science and engineering designated and related programs be bridged? Given the proliferation of materials science courses in related departments, is there a need for designated materials science and engineering program?

NSF Workshop Summary: Accept the reality that others will wish to teach "their version" of overlapping subjects (thermo, solid state physics, etc.) and take advantage of that by eliminating redundancy and encouraging cross-listing while trying to work with others to jointly teach some of these. Yes, there continues to be a need for the undergraduate degree, especially to address the specialty needs of many industrial employers.

LHS Comments: I'd say that the first step to understanding the roles of materials in the educational portfolios of "others" might be a National Academies study of materials education in the USA including some reference to the rest of the world as well. Many of the questions raised here in today's discussion can only be addressed in the global context, recognizing the changing character of materials development and manufacturing. Part of the answer to these related programs is to work with them (through joint commissions of two professional societies) to clarify the nature of the overlapping content and concept of the two fields. For example, as we have found in the area of corrosion, the people teaching the MEs and CEs who need this content are themselves not knowledgeable in corrosion and find little reference to the subject in the texts they use (written for them by our community). We need some structure to attack this problem, perhaps similar to that used in the UK and derived from the work of Ashby (UK Centre for Materials Education).

LHS: General Comments on university materials education

Before any discussion of materials education at the university level, one must characterize the state of current departments, materials education in non "materials" departments and how to influence that, and the enormous issues associated with continuing education.

We continue to be weaker than counterpart fields because of our fragmented society structure. Clearly, we are <u>not</u> a single community. If we think broadly of all those who participate in materials research and application, our "community" now includes dozens of professional societies and professions. Narrowing the focus to only those related in some rather direct way to our "materials" departments, we still have several entities including professional societies (ASM, MRS, TMS, ACerS, NACE, AWS, etc., etc.) and an independent educational

publishing group (The Journal of Materials Education). Currently, with little overlap or collaboration, TMS is focused on university levels, ASM on high school, and MRS on reaching the general public and young people with informal education projects. Limited community action occurs at society meetings where best practices are shared (this is rapidly increasing at both MRS and MS&T), through the Federation of Materials Societies (which now includes materials education in its mandate as well as communication with Federal agencies and The Congress) and the University Materials Council. None of these present structures has stepped forward to take the responsibility for the collaborative actions contemplated in these discussions. UMC would seem to be most "responsible" for the undergraduate and graduate issues, but the UMC structure has no budget, no staff support, and no large body of volunteers ready to participate (most faculty will focus on education issues for a small fraction of their time, especially when they have some assigned department responsibility, and then move on).

So what should we do? I advocate that one society step up and take responsibility for materials education in the university departments. I am a member of TMS, ASM and MRS. I have had leadership roles in both ASM and MRS. After some examination of their structure and history, I would suggest that it be TMS that takes this role, with ASM, MRS, ACerS and others cooperating in various ways consistent with their current roles and strategic plans. I suggest TMS because of its traditional leadership in ABET (with more recent participation from NICE), its membership size (mostly USA, mostly from technical areas related to those of many university departments) and its extensive continuing committee structure. MRS is of comparable membership size, but many of these members are non-USA, and many are from physics and chemistry departments. ASM is much larger in membership and endowment. It has, of course both a well-funded Education Foundation and a strong committee structure, but no real education experience at the university level. Current strategic plans within ASM include some university education content through the continuing education path, and, of course cooperative student involvement through Materials Advantage. They may be interested in collaborative efforts on other issues.

What are the prime responsibilities that the TMS might assume? The NSF workshop (and a proposed NRC study) would help to flesh out this agenda, but I think that we might see a UMC-TMS committee structure that would set priorities and seek volunteer members from all points of origin, depending on the issue. TMS staff and publications could centralize the effort. ABET work would continue to be one element of this work. I'd like to see a project to clarify the Body of Knowledge in undergraduate (and possibly graduate) materials science/engineering, one to assemble data on current course structures, outlines, books and supplementary information etc., one to address the issue of employment opportunity, one to examine issues related to the professional masters degree, one on continuing education, one to work on links with educational committees in ASME, ASCE, IEEE, and AIChE, and other issues as they develop.

I have had preliminary discussions with current leadership of TMS and find an appetite to address some, if not all of these issues. I believe it may now be up to UMC to identify priorities and begin the serious discussions with TMS.

More Detail on UMC/Society Collaboration

1. ABET work would continue to be one element of this work.

2. Clarify the Body of Knowledge in undergraduate (and possibly graduate) materials science/engineering. (Body of Knowledge is a compendium of things ((concepts and data)) that we expect to find in all (or only some) materials education programs.) Preliminary work by Kevin Jones and Susan Sinnott suggest a format for identifying what is currently being taught. Extend their work to include all members in UMC. Perhaps the next step is to look down one layer from course titles to “concepts”. Then move on to learn what is being taught in other engineering, chemistry and physics under the rubric of a materials “major”. One may imagine that the body of knowledge will be formulated in such a manner that “materials chemistry” will show the overlap between chemistry and some (or many) materials departments. Similarly for electronic materials, polymers, etc. One may also see connections across the transition between materials design and design with materials (e.g. in ME and EE) and materials processing and processing of materials (e.g. in ChE).Questions regarding “core” courses (knowledge) are best discussed in the context of the broader available information of a Body of Knowledge.

3. Assemble and display data on current course structures, outlines, books and supplementary information, etc. Organize the templates and invite participation by members of UMC. This information could be open to all or restricted to UMC members or some hybrid. This information might be kept on only web site or displayed on the sites of several participating societies. Currently ASM has the most sophisticated search capabilities, so it may be the best site, but if only modest searching is required, any siting will do.

4. Employment opportunities. All departments track employment of graduates, but I believe there is no sharing. Imagine a single searchable site displaying all of the companies who employed our graduates last year (or during the last several years). Once initiated, access to this page by companies could help them see which schools were sending students to their peer companies. Within the rules governed by privacy considerations, companies could enter data on what their new employees were doing. General (or perhaps even specific) salary information might be displayed. Imagine how effective such a page could be in attracting students at all levels.

5. Examine issues related to the professional masters degree/continuing education. I think these issues are linked, but they could readily be separated. What drives both is the fact that we cannot be both broad and deep (“horizontal”

and “vertical”) with limited courses in the undergraduate program. Masters *vs.* a few continuing education courses is an issue of marketing, cost and delivery as well as content. UMC may not need others to explore this particular issue.

6. Links with educational committees in ASME, ASCE, IEEE, and AIChE. This is clearly a society issue. Working with UMC, one materials society (or a joint committee) should begin with a summit workshop to discuss issues and then move on from there. This item should probably precede the second element in Item 1.